Michael Baker INTERNATIONAL

We Make a Difference

Technical Memorandum

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DATE: October 27, 2020

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SUBJECT: **E03463, Supp. 7, Signal Prog. Support**
City of Reading TSAMS Use-Case Project
DRAFT Traffic Signal Maintenance Plan

The City of Reading, Pennsylvania (the City) requested Green-Light-Go funding from PennDOT to conduct a study on the current status on their traffic signals. The City indicated they have not had a traffic engineer on staff for several years and that most of their traffic signal attention has been directed to responsive maintenance. PennDOT sourced an existing contract with Michael Baker International (MBI) for the Traffic Signal Asset Management System (TSAMS) to assist the city by evaluating their traffic signal assets and providing direction on how to more proactively manage them. The hope is that this project will also serve as a case study for TSAMS functionality and usage and will help to inform future TSAMS developments.

Michael Baker International (MBI) has completed quantitative and qualitative data collection to establish the current traffic signal equipment conditions for the City of Reading, Pennsylvania. During a period of five weeks in Spring 2020, the 131 signalized intersections that are owned and operated by the City of Reading were evaluated. A field inventory was conducted at each signal, which consisted of (1) verifying on-street information against the Traffic Signal Asset Management System (TSAMS) and the signal permit and (2) determining the condition and functionality of the following equipment:

- Signage
- Vehicle/Pedestrian Signal Housings
- Structures
- Junction Boxes
- Preemption
- Vehicle/Pedestrian Detection
- Cabinet
- Pavement markings

In addition, all intersections were checked for Manual on Uniform Traffic Control Devices (MUTCD) compliance, resulting in a list of maintenance-related corrective actions and modification-related corrective actions. Based on the results of the field inventory and the MUTCD compliance assessment, the MBI team has identified strategies to mitigate any immediate issues and has developed a plan for future signal maintenance and upgrades.

City of Reading
Traffic Signal Maintenance Plan

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Introduction

The City of Reading wants to more proactively manage the physical assets associated with the 131 signalized intersections that are owned and operated by the City.

Current Situation

The City of Reading's current approach to traffic signal asset management has been relatively passive/reactive. The City does not have a municipal traffic engineer on-staff who can evaluate and proactively manage the signal equipment and operations. The City hires a private contractor (Telco, Inc.) to provide responsive signal maintenance and install new traffic signals. However, this primarily passive/reactive approach to traffic signal maintenance comes at a price.

Without staff dedicated to the proactive management of the City's traffic signals:

- **20% of the City's 4,840 signal assets are in either "fair" or "poor" condition.**
- **95% of the traffic signals need at least one corrective action to meet national standards**, as outlined in the Federal Highway Administration (FHWA) Manual on Uniform Traffic Control Devices (MUTCD).
- **82% of traffic signal permits are no longer consistent with current conditions** (i.e. the permits have not been updated to reflect current conditions and the modifications that have made in the field have not been officially reviewed or permitted by PennDOT). *The number of inconsistencies between the permit and current conditions can range from 1 to 29 per intersection, with an average of 6 inconsistencies per intersection.*

Desired Situation

The City of Reading's goal is to "provide an effective and efficient traffic control system and devices that maximize safety, quality, reliability, comfort, and understandability, and minimize travel time, inconvenience, and expense for the traveling public and the taxpayers". **By proactively managing the traffic signal assets, the City will be able to more effectively leverage traffic signal funding to strategically address the existing needs and plan for future maintenance/upgrades.**

Path to Get There

The first step towards proactive traffic signal management is the evaluation of current inventory (i.e. answering the following questions: What traffic signal equipment do we own? What condition is it in? Does it meet current standards? Is it correctly permitted?). The next step is the documentation of the corrective actions that must be taken to resolve any existing issues. The final step is strategically outlining how those corrective actions can be programmed, along with the necessary regular, preventative equipment maintenance, to gradually improve the overall traffic signal system.

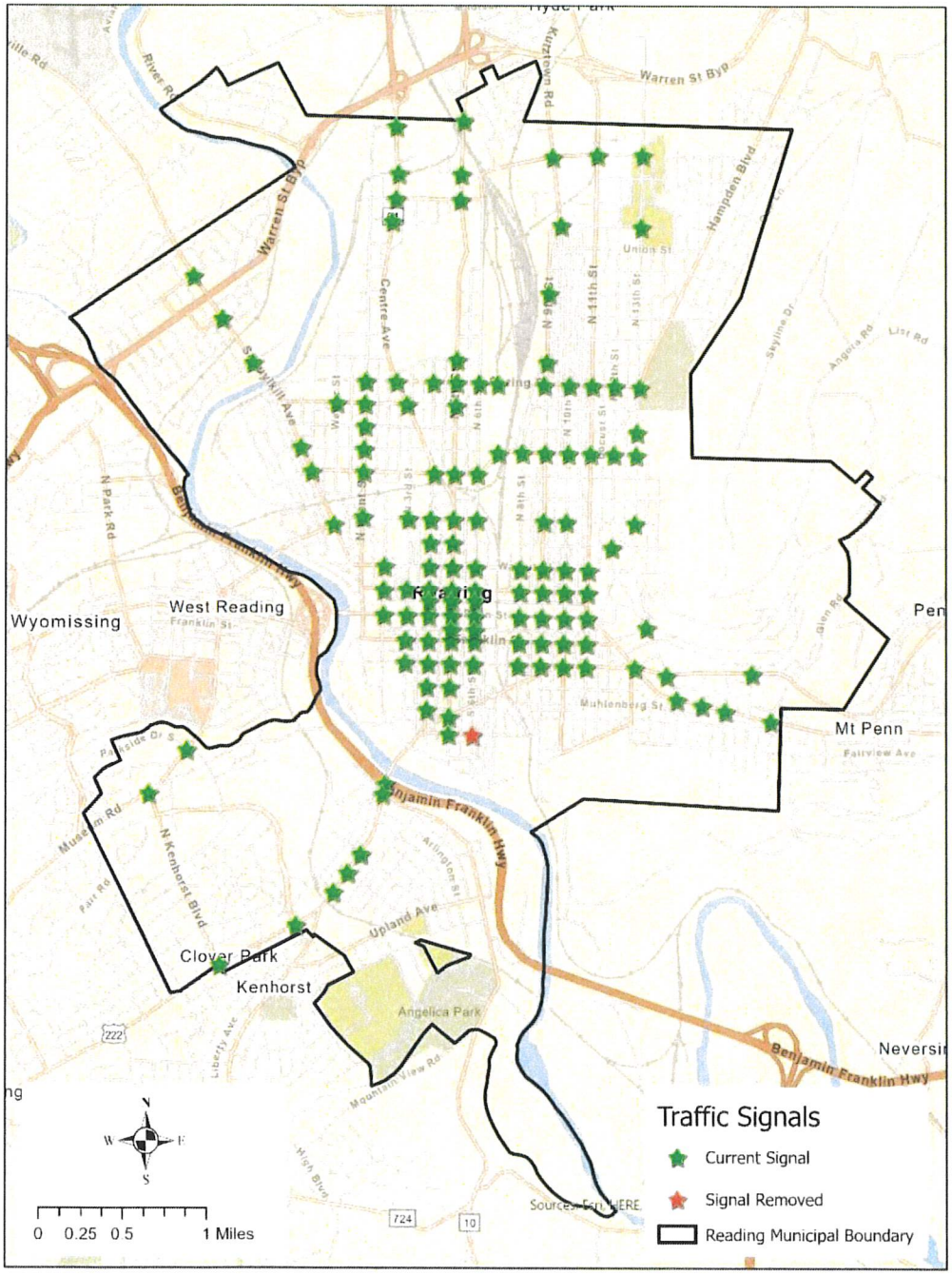
This traffic signal maintenance plan:

- **Inventories** the traffic signal equipment assets
- **Evaluates** the current conditions of the equipment, the accuracy of the traffic signal permits, and compliance with national standards
- **Identifies** a recommended approach to future signal maintenance and upgrades

Inventory

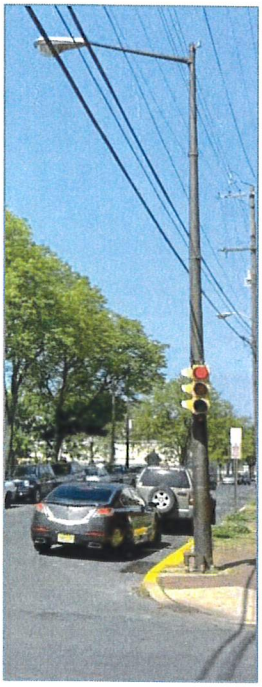
Overall Summary

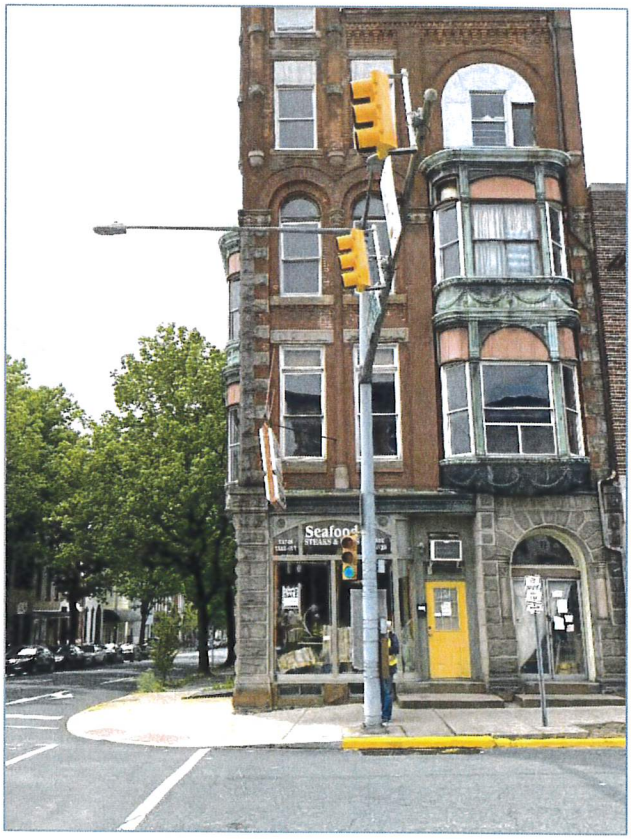
As of May 2020, the City of Reading owned 131 traffic signals. One signal (at the intersection of Laurel Street and South Sixth Street) is in the process of being removed by the City and was therefore not included in this evaluation and maintenance plan. The final total is: 130 traffic signals owned, operated, and maintained by the City of Reading.



The 130 traffic signals within the City contain 4,840 individual assets, as summarized below:

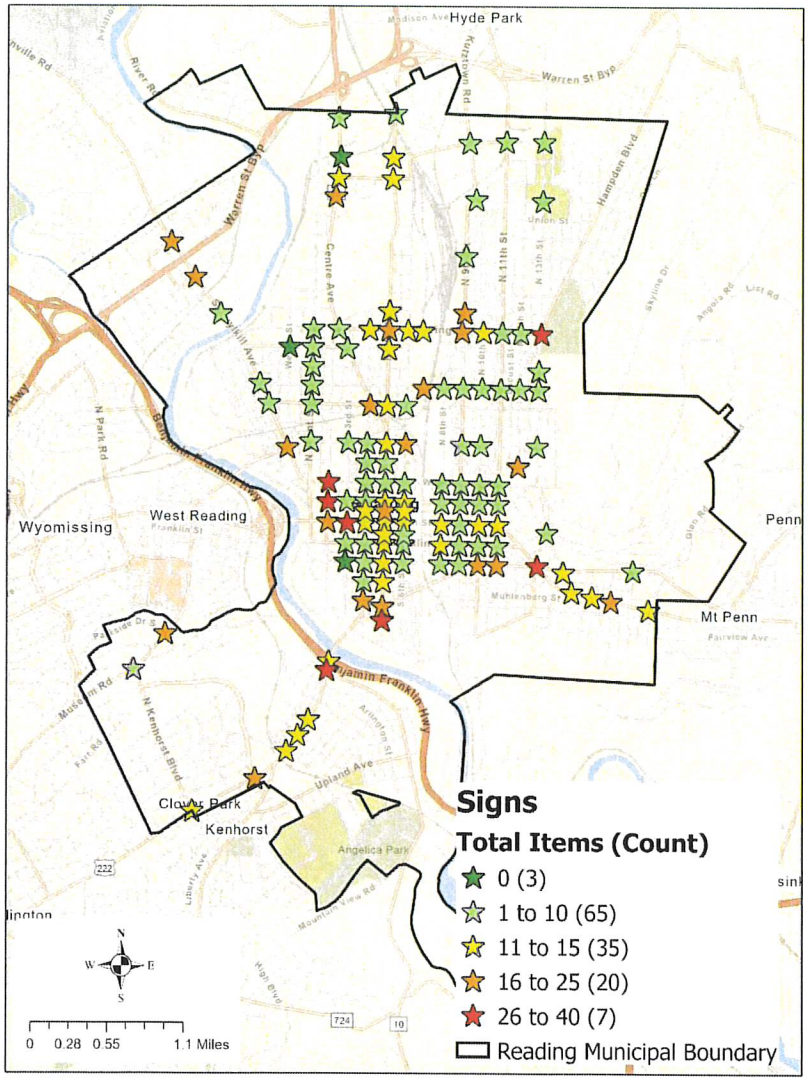
Item Type	Total Number of Items	Average Number of Items per Signal
Signs	1,457	11
Vehicle Signal Housings	782	6
Pedestrian Signal Housings	644	5
Structures	630	5
Junction Boxes	240	2
Preemption Devices	34	0
Vehicle Detection Devices	92	1
Pedestrian Detection	231	2
Cabinets	110	1
Pavement Markings	616	5
All Signal Items:	**4,840**	**37**





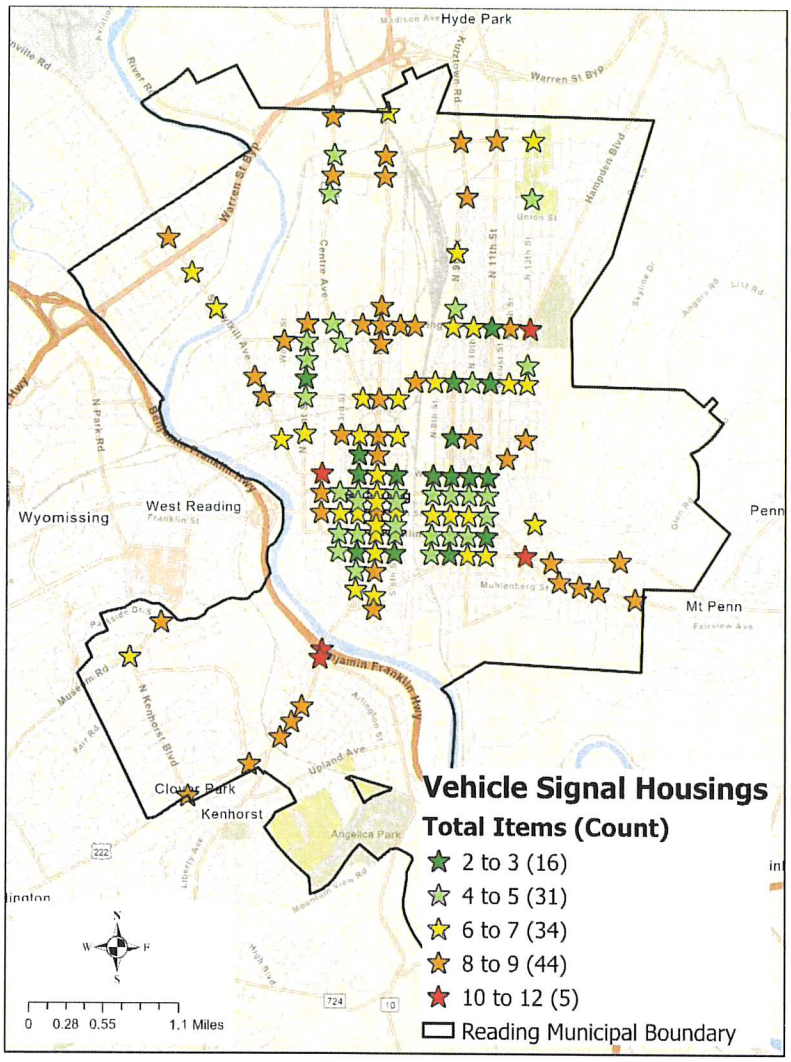
Signage

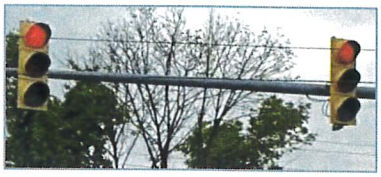
There are 1457 total signs associated with traffic signals within the city. The number of signs per intersection range from 0 signs at 3 different intersections to 40 signs at the intersection of Washington Street and 2nd Street.



Vehicle Signal Housings

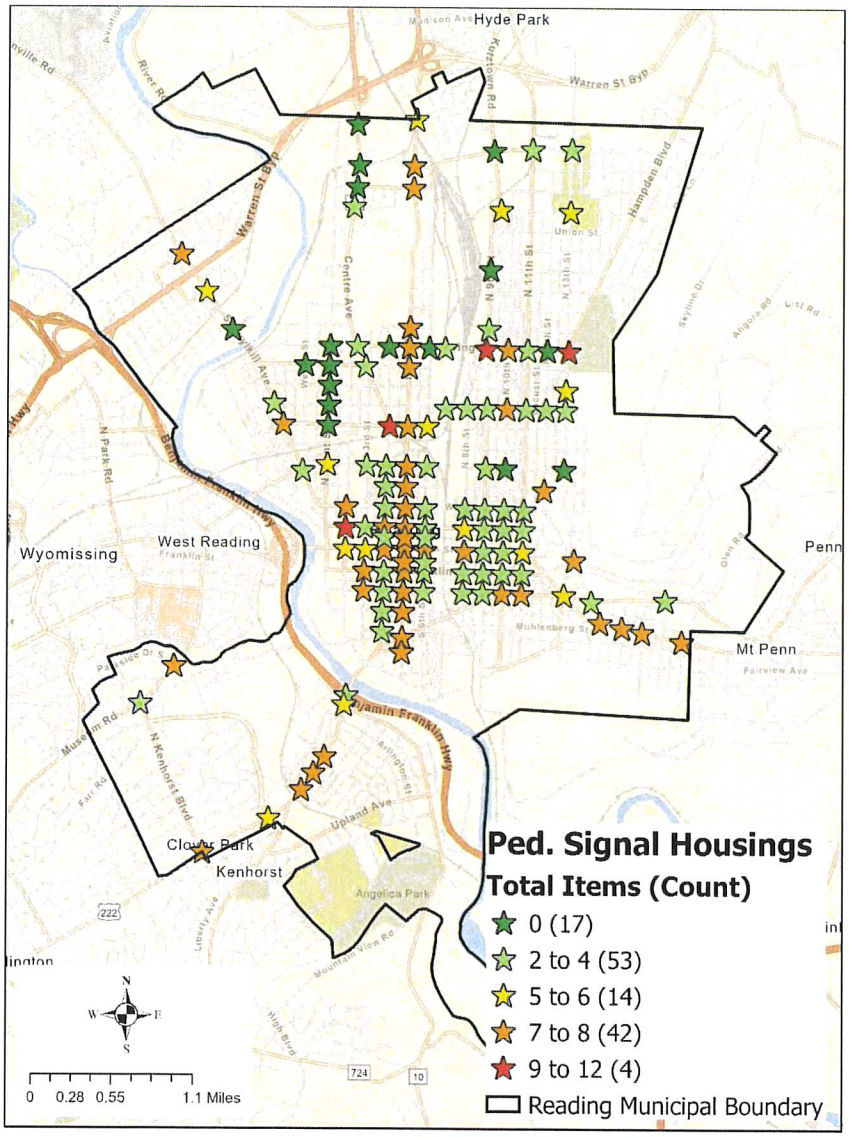
Vehicle signal housings are the signal housings used to control the flow of vehicle traffic. In some instances, these signal housings can also be for pedestrian traffic, but if their main objective is control vehicle traffic they were categorized as vehicle signal housings. There are 782 vehicle signal housings in the city. The number of vehicle signal housings per intersection ranges from 2 housings at 10 different intersections to 12 housings (at the intersection of Morgantown Road and Lancaster Avenue).

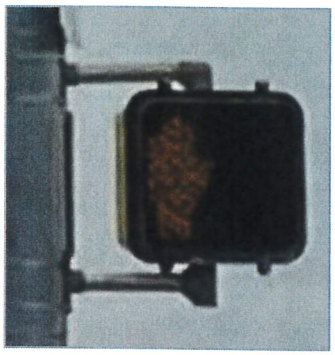


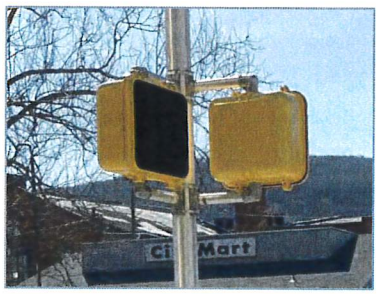


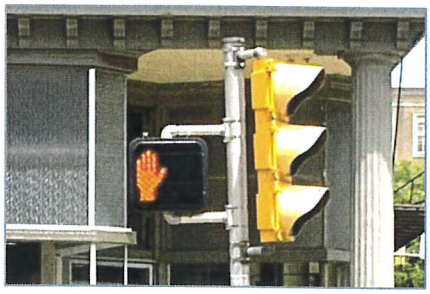
Pedestrian Signal Housings

Pedestrian signal housings are used exclusively to control pedestrian traffic through an intersection. These housings can range from a simple red, yellow, or green housing to a countdown signal housing. There are 644 pedestrian signal housings in the city. The number of pedestrian signal housings per intersection ranges from 0 housings at 15 different intersections to 12 housings.



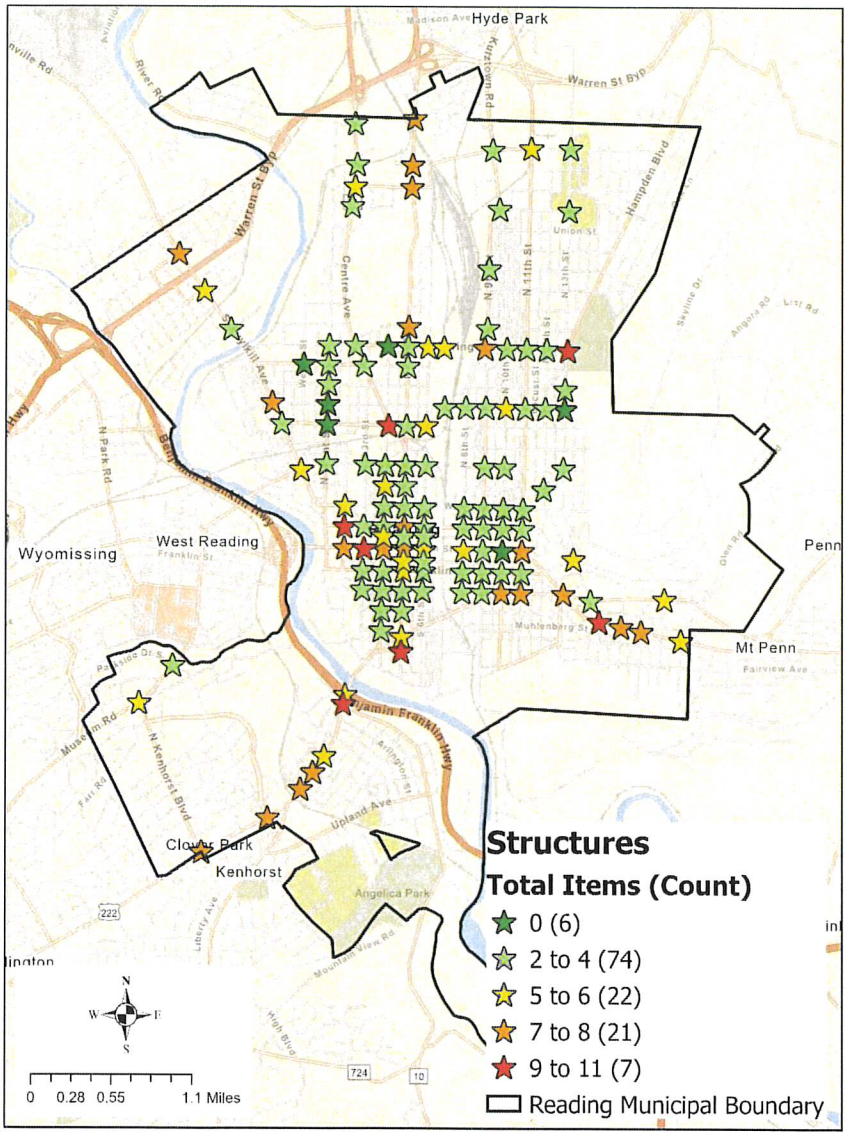






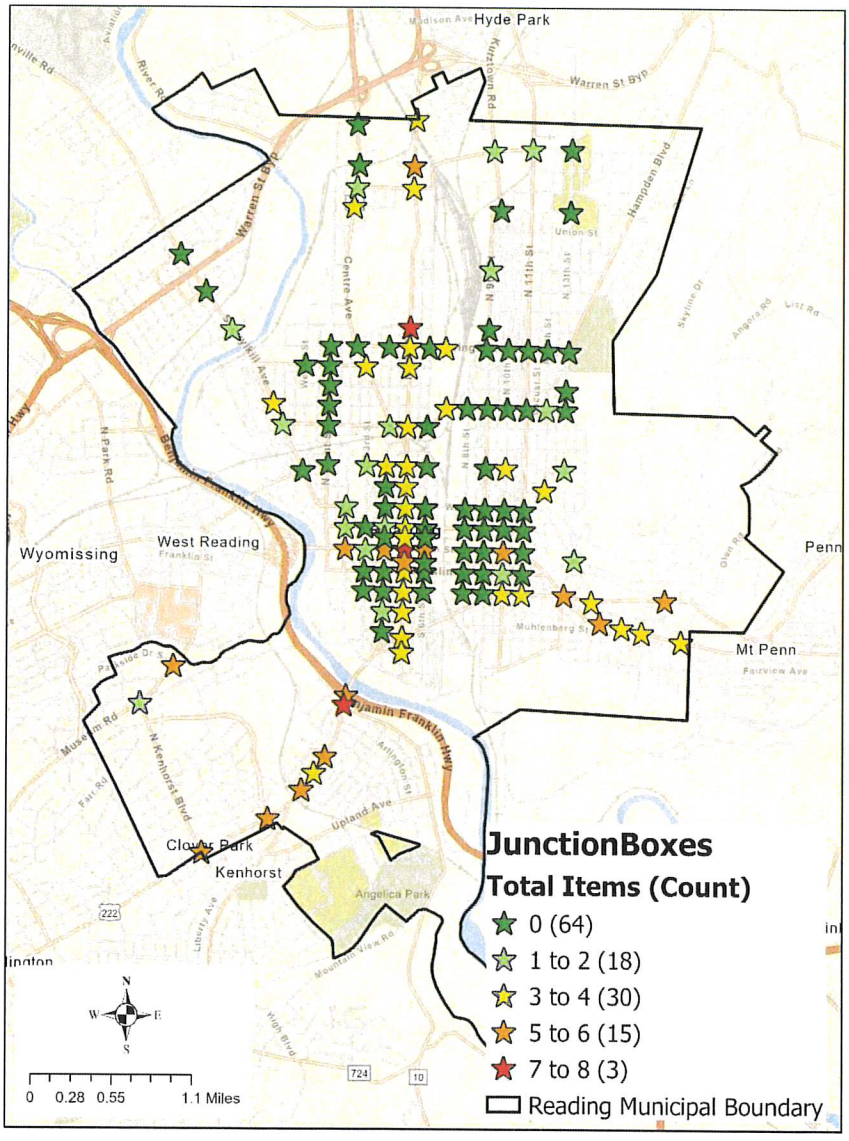
Structures

A traffic signal structure is any item that provide the main support for the signal housings, such as a pole or mast-arm. *While some of the traffic signal equipment was mounted on utility poles, these poles were not included in this evaluation. This resulted in some intersections having 0 structures associated with them.* There are 630 traffic signal structures in the city. The number of traffic signal structures per intersection ranges from 0 structures at 6 different intersections to 11 structures at the intersection of Washington Street and Second Street.



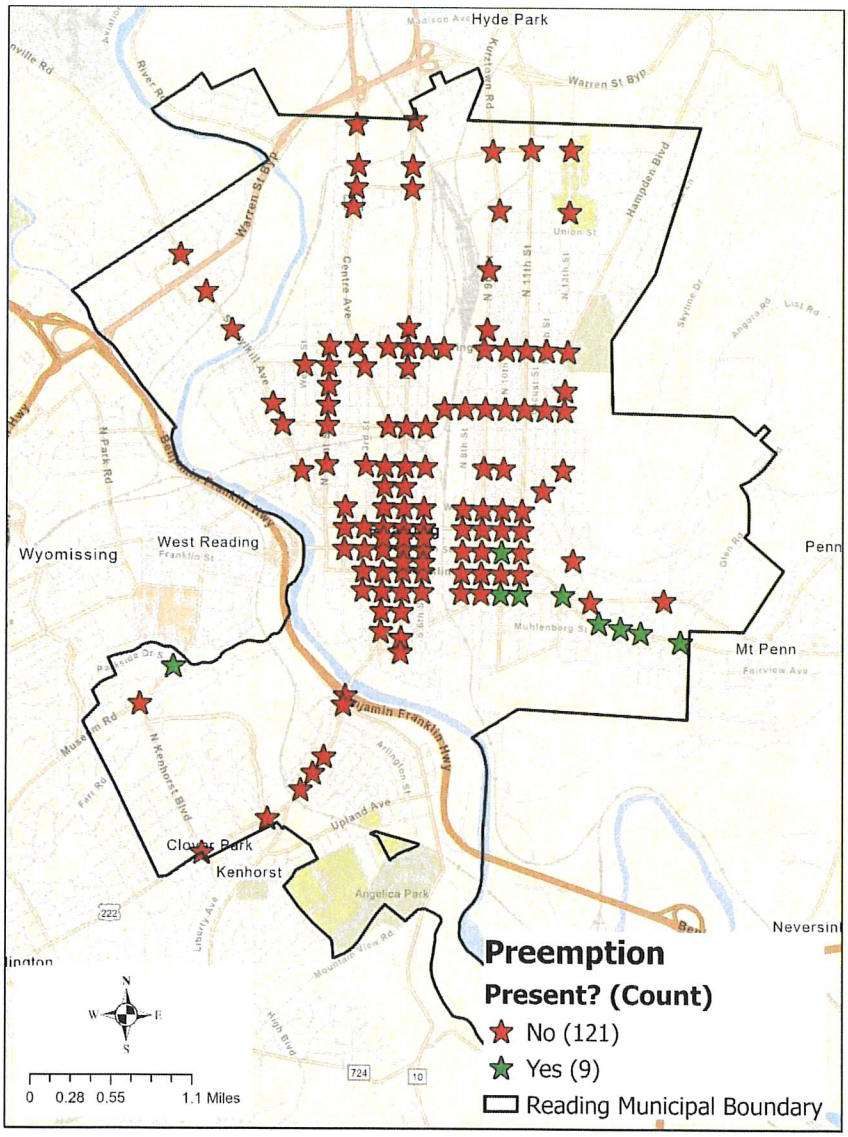
Junction Boxes

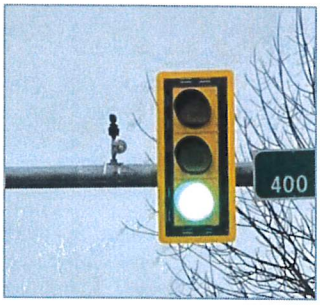
Junction boxes are used to run electrical wiring for the traffic signal. These boxes are not always represented on the permit, their lids are not always labeled, and they can be buried under dirt and debris. Every effort was made to accurately locate and identify every junction box, but due to the mentioned issues this may not be a complete inventory. There are 240 junction boxes identified within the city. The number of junction boxes per intersection ranges from 0 boxes at 64 different intersections to 8 boxes at the intersection of Fifth Street and Penn Street.



Preemption

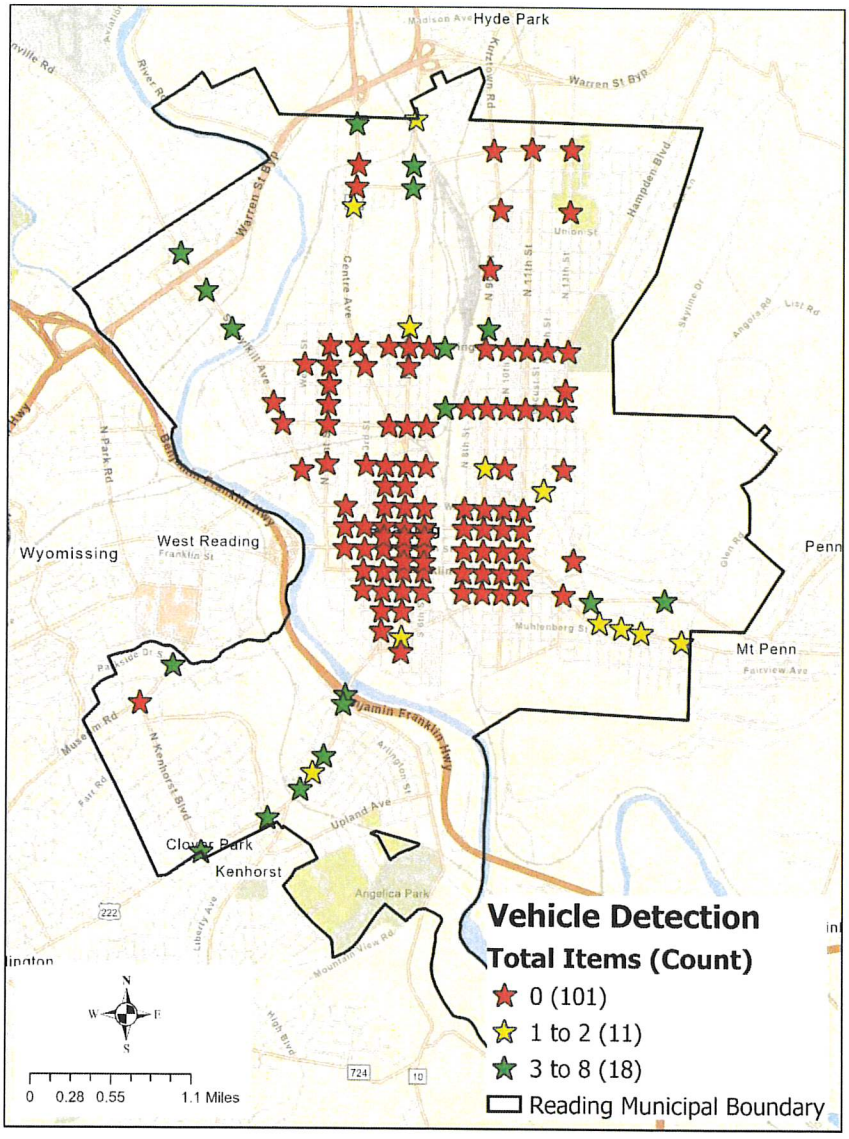
Traffic signal preemption is used to interrupt the typical functionality of a traffic signal. In all examples within Reading, the preemption is used to allow the uninterrupted movement of emergency vehicles. Emergency preemption is present at only 9 intersections within the city (7%). There are either 3 or 4 devices at these intersections, depending on the number of approaches to the intersection.

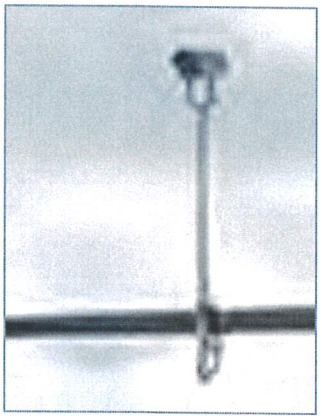


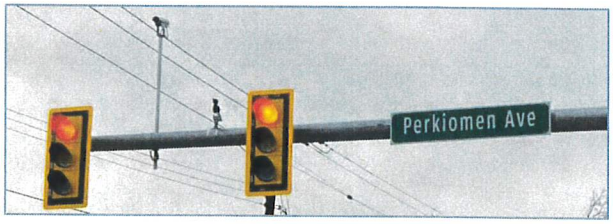


Vehicle Detection

Vehicle detection passively detects the presence of a vehicle at an approach to an intersection and alerts the signal controller. There are many types of detection devices available, but the main type of detection used in Reading is either a loop detector located in the pavement or a video detector located on a signal structure. There are 29 intersections within the city that have at least one vehicle detection device. The number of detectors range from 1 detector at 2 different intersections to 8 detectors at the intersection of Lancaster Avenue and Kenhorst Boulevard.

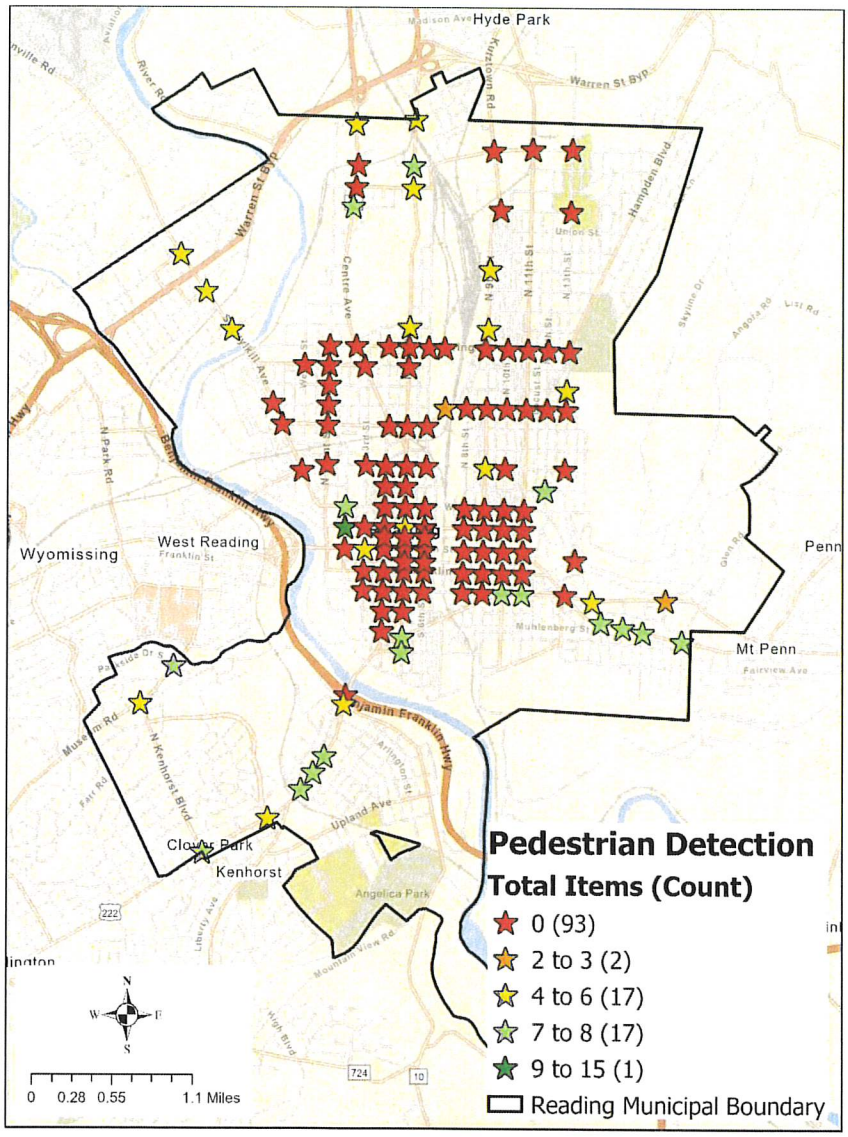


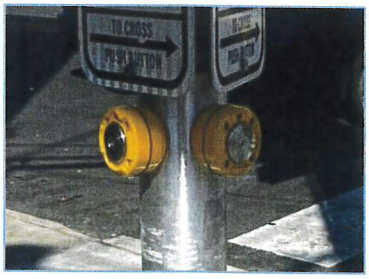




Pedestrian Detection

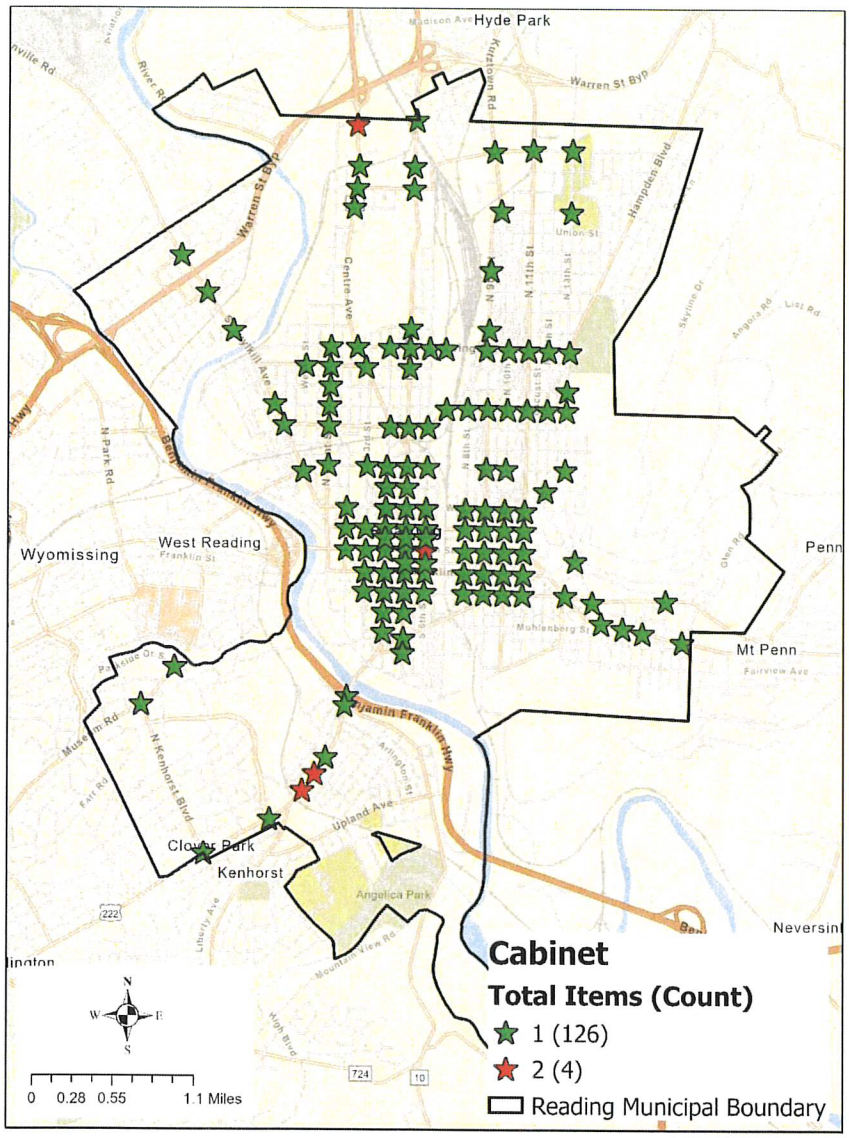
Pedestrian detection alerts the signal controller that a pedestrian is present (in the City of Reading, this detection occurs through the pedestrian's activation of a push-button). There are 37 intersections with pedestrian detection. The number of detectors at these intersections range from 2 detectors at 2 different intersections to 15 detectors at the intersection of Washington Street and Second Street.





Cabinet

The signal cabinet is the location of the signal controller, the signal flasher, and most of the other electronics involved with a traffic signal. In most cases there is 1 cabinet per intersection, but in some cases there are more. In the cases where there are more than one, usually the second cabinet is used to house the battery backup equipment. In Reading, each traffic signal has at least one cabinet and 4 signals have a second cabinet.

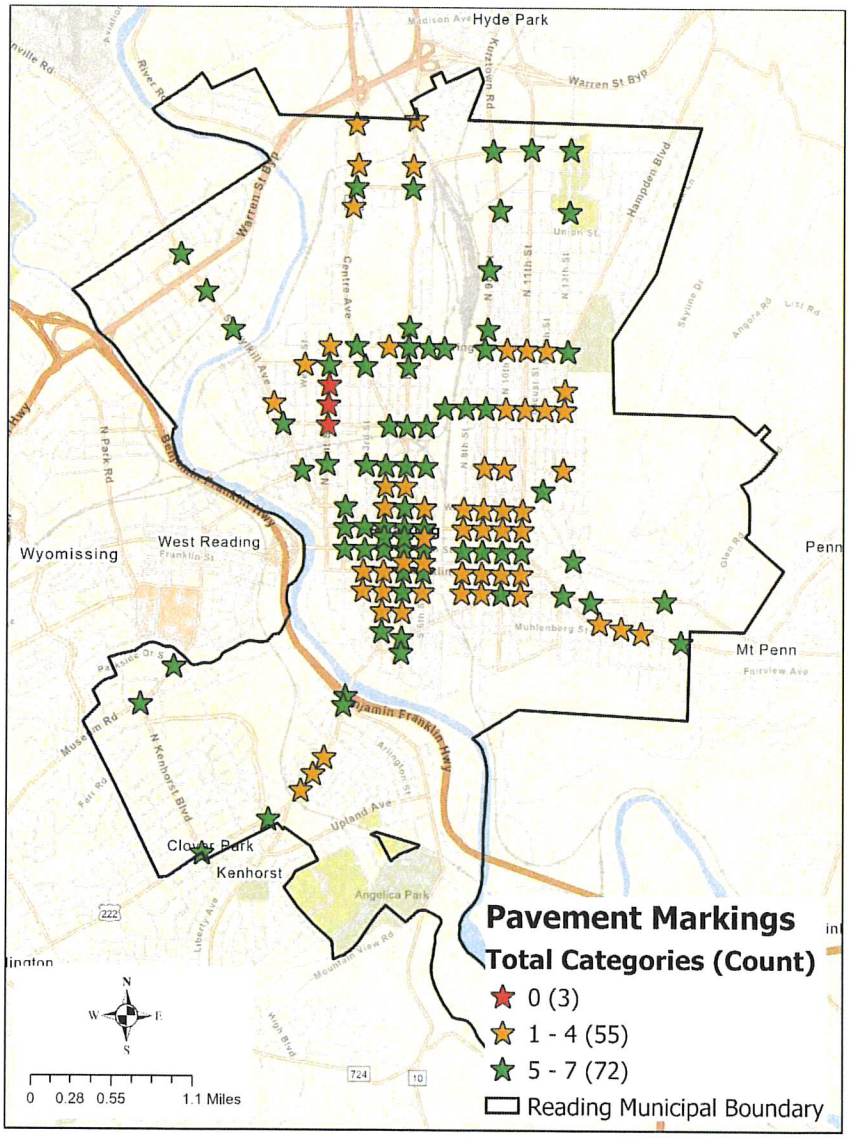


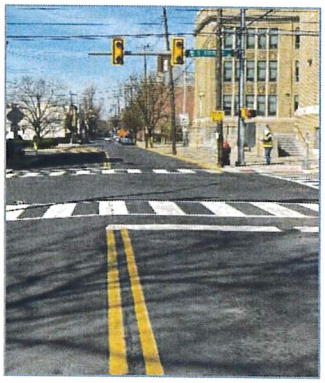
Pavement Markings

Pavement markings are the painted lines and symbols on the roadway pavement that provide traffic control information to roadway users. Due to the wide variety of pavement markings, they have been grouped into seven categories during this assessment:

- Crosswalks
- Text
- Arrows
- Lane Lines
- Stop Bars
- Center Lines
- Other

Each one of these categories was assessed as a group at each intersection. If a category exists at an intersection, regardless of the number, amount, or size of the pavement markings within that category, it was counted and rated as a one item. There are 616 total pavement marking groups within the city. The number of groups range from zero pavement markings at 3 different intersections to all seven pavement marking groups existing at four intersections.





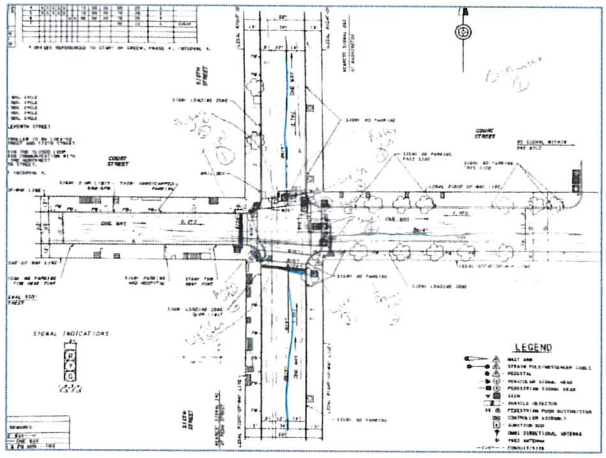
Condition Assessment, Permit Verification, & Compliance Review

Introduction

During the collection of the City's physical traffic signal asset inventory, there was an assessment of both the equipment conditions, the accuracy of the traffic signal permit, and compliance with current national standards.

The Process:

Site visits were conducted at each intersection between March 9th and May 21st, 2020. The traffic signal permits were downloaded from TSAMS and printed in advance of the site visits and these physical copies of the permits were used to mark any discrepancies between the permit and the current field conditions. While verifying the permit accuracy, the relative condition of the traffic signal assets was also noted on the permit. Photographs were taken to document the current state of the intersection.



After the site visits, the marked-up permits were scanned and uploaded with the photos into a distinct folder for each intersection. The marked-up information on the permits was used to populate an Excel spreadsheet. The photographs were used to verify the assessment completed in the field.

The traffic signal assets were divided into 10 categories. The Pavement Marking category was further subdivided in to 7 subcategories. These categories and sub-categories are summarized below:

- Signage
- Vehicle Signal Housings
- Pedestrian Signal Housings
- Structures
- Junction Boxes
- Preemption
- Vehicle Detection
- Cabinet
- Pavement Markings
  - Crosswalks
  - Text
  - Arrows
  - Lane Lines
  - Stop Bar
  - Center Line
  - Other Markings

Finally, the photographs taken during the site visits were also used to later verify the traffic signals' compliance with the FHWA Manual on Uniform Traffic Control Devices (MUTCD).

Condition Assessment

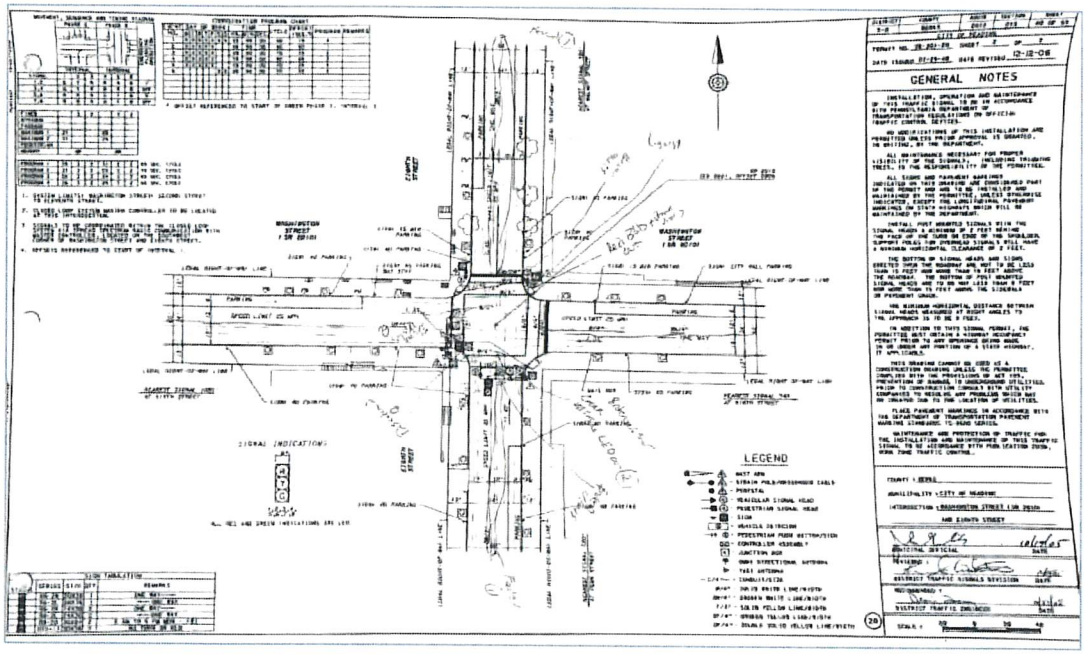
The inventoried signal items and equipment were assigned condition ratings on a score from 1 to 3:

- Condition Rating 3 → "Good"
  An item given a rating of 3 will function as intended, be free of damage, rust or any other visible structural deficiencies.

- Condition Rating 2 → "Fair"
  An item given a rating of 2 will function as intended, will have minor signs of wear and tear, slight surface level rust or minor discoloration. Items rated at 2 should be monitored to prevent degradation to condition rating 1.

- Condition Rating 1 → "Poor"
  A rating of 1 is an indication that the item does not function as intended, poses a risk of failure, and/or needs repaired or replaced in the short term.

Examples of each rating level, for each category, are found in Appendix A.



Recording Data: Condition Assessment

For the 10 main condition assessment categories, each individual signal asset item was counted based on its condition rating (i.e. 3 signal housings at rating 2, 2 junction boxes at rating 1, etc.). Pavement marking subcategories were rated by analyzing the entirety of that item type for the intersection and given one condition rating (i.e. the lanes lines are rating 2, the crosswalks are a rating 3, etc.). Those subcategory ratings were summed to populate the Pavement Marking main category. For all the categories (and subcategories): if an item received a rating less than 3, a comment noting the reason for the lower rating was added to the comment field.

Example:

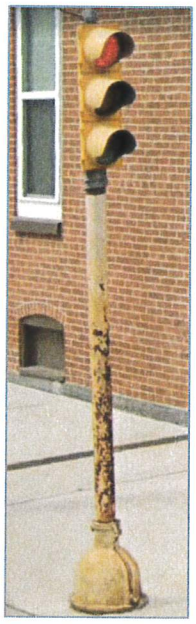
In the example below, the intersection had 19 total items. It had 16 actual items and 3 categories of pavement marking. Of those items, 11 main category items received a condition rating of 3, 4 items received a rating of 2, and 1 item received a rating of 1. Of the pavement marking category, three subcategories received a rating of 1. One sign was rated at level 2 and a comment was provided that noted the sign's nomenclature and a brief description of the issue. When available, these comments will include the identifying number listed on the traffic signal permit.

Table 3. Condition Rating for an Example Intersection:

Item Type	Total Items	Condition Rating 3	Condition Rating 2	Condition Rating 1	Comments (Please leave comment for any Ratings of 1 or 2)
Signage	4	3	1		R6-2R Cracked
Vehicle Signal Housings	3	1	2		1 - Paint Faded; 3 - Missing Visor
Pedestrian Signal Housings	3	2	1		6 - Paint Faded
Structures	5	4		1	2 - Rusty
Junction Boxes	0				
Preemption	0				
Vehicle Detection	0				
Pedestrian Detection	0				
Cabinet	1	1			
Pavement Marking	3	0	0	3	
Crosswalks	1			1	Faded/Missing
Text	0				
Arrows	0				
Lane Lines	1			1	Pvmt. Mkgs. Missing - 2 approaches
Stop Bar	1			1	Pvmt. Mkgs. Missing - 2 approaches
Center Line	0				
Other Markings	0				
TOTAL	**19**	**11**	**4**	**4**	**n/a**

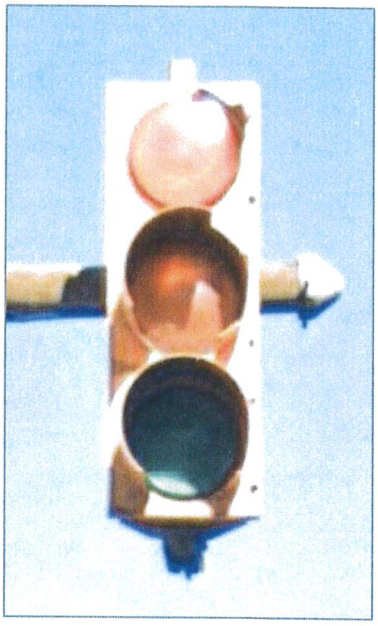
In this example, vehicle signal housing number 1 had faded paint and number 3 was missing a visor. Additionally, structure number 2 was rusty. See example images 1, 2, and 3 below.

Example Image 1 – Rusted structure



Example Image 2 – Faded vehicle signal housing

Example Image 3 – Broken vehicle signal housing



There were three subcategories of pavement markings either present or indicated on the permit. The crosswalk lines are very faded and almost nonexistent. Stop bars are missing from both approaches and the lane line is missing from the approach on the right of the image below. These factors led to all of these categories receiving a rating of 1.

Example Image 4 – Faded and missing pavement markings

Permit Verification

Permits were verified by comparing current field conditions and current traffic signal permits. If an item was missing from the permit, it was manually noted on the permit (with an approximate location and a description). The description could be a sketch of the item, such as a sign, or a general description like 3 – 8" Signal Housing.

Recording Data: Permit Verification

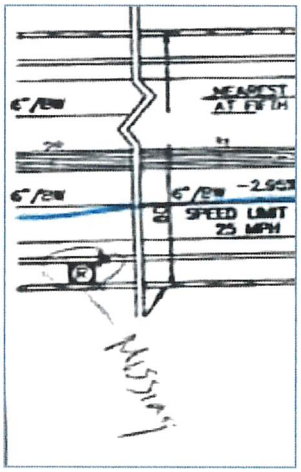
Permit verification data input followed the same process as the condition assessment, where each individual discrepancy was counted (when comparing the current field conditions to what the permit was showing). Pavement marking subcategory discrepancies were noted for an entire subcategory rather than for an individual marking.

Example:

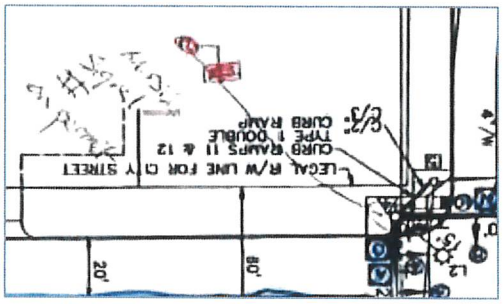
In the example below, one sign on the permit was missing from the field (see example image 1). A sign with the symbol "R" a R3-7R (Right Lane Must Turn Right) was noted on the permit. Upon inspection of the area the sign was not located as indicated. A pedestrian signal housing existed in the field but was not shown on the permit (see example image 2). The field review found that a structure had two pedestrian signal heads, instead of just one (see example image 3).

Permit Non-Match	Missing from Field	Missing from Permit	Different from Permit	Other?	Comments (Please leave comment for any Non-Match)
2	1	1			R6-2L missing from field on SB approach, R6-1L is missing from permit on SB approach

Example Image 1 - Permit indicating missing sign



Example Image 2 - Permit indicating missing pedestrian signal head from permit



Example Image 3 - Field showing two pedestrian signal heads

Compliance with National Standards

Photographs taken during the intersection site visits were used to verify the traffic signals' compliance with the national standards in the FHWA Manual on Uniform Traffic Control Devices (MUTCD) and Americans with Disabilities Act (ADA). This effort was completed back in the office, due to the more time-consuming nature of the evaluation.

The 32 MUTCD "SHALL" requirement categories, along with the ADA requirements, were analyzed for each approach to the intersection. Some examples of the "SHALL" requirements are shown below.

Example "SHALL" Requirements from the 2009 FHWA MUTCD:

Section 4D.13 Lateral Positioning of Signal Faces

Standard:

01 **At least one and preferably both of the minimum of two primary signal faces required for the through movement (or the major turning movement if there is no through movement) on the approach shall be located between two lines intersecting with the center of the approach at a point 10 feet behind the stop line, one making an angle of approximately 20 degrees to the right of the center of the approach extended, and the other making an angle of approximately 20 degrees to the left of the center of the approach extended. The signal face that satisfies this requirement shall simultaneously satisfy the longitudinal placement requirement described in Section 4D.14 (see Figure 4D-4).**

Section 4D.16 Lateral Offset (Clearance) of Signal Faces

Standard:

01 **Signal faces mounted at the side of a roadway with curbs at less than 15 feet from the bottom of the housing and any related attachments shall have a horizontal offset of not less than 2 feet from the face of a vertical curb, or if there is no curb, not less than 2 feet from the edge of a shoulder.**

One corrective action was noted for every requirement that was out of compliance, for every intersection approach. These corrective actions were then categorized as either maintenance corrective actions or modification corrective actions, based on the recommendation of the reviewer.

Maintenance Corrective Actions	Modification Corrective Actions
Actions that need maintenance to remedy such as replacing signs or prohibiting parking withing 30 feet of a crosswalk.	Actions that require a modification to the intersection such as relocating signal housings overhead or revising a signal head and its corresponding phasing.

Recording Data – Compliance with National Standards

A spreadsheet was created listing the 32 requirement categories. These 32 requirements were verified for all approaches to the intersection by a traffic engineer. These requirements are summarized in the "Requirements" tab in the spreadsheet (shown on the following page).

If an item is out of compliance, it is noted with a "Y", and a corrective action is suggested based on the type of action. If the item does not apply to the approach, it is noted with an "NA" and if there are no issues, it is noted with an "N". A count of each corrective action category of corrective action was totaled for each intersection.

MUTCD & ADA Compliance Categories

Categories:	Compliance Issues by Intersection Approach			
	NB	SB	EB	WB
Vehicle Signal Heads				
Head Configuration/Meaning	N	N	N	N
Head Size	N	N	N	N
Number of Heads	N	N	N	N
Head Visibility	N	N	N	N
Lateral Position	Y	N	N	N
Longitudinal Position	N	N	N	N
Mounting Height	N	N	N	N
Vertical Clearance	N	N	N	N
Signal Indications - Left Turn Movements	NA	NA	NA	NA
Signal Indications - Right Turn Movements	NA	NA	NA	NA
Noncompliant features (Strobes)	N	N	N	N
Backplates	N	N	N	Y
Visors	N	N	N	N
Other Signal Elements				
Clearance Intervals	N	N	N	N
Preemption Control	NA	NA	NA	NA
Flashing Operation	N	N	N	N
Sign Nomenclature and Colors [1]	N	N	N	N
Pavement Markings	Y	N	N	N
Categories:	**Compliance Issues by Intersection Quadrant**			
	NE	**NW**	**SW**	**SE**
Signal Support Offsets [2]	N	N	N	N
Pedestrian Signal Heads				
Head Configuration/Meaning	N	N	N	N
Head Size	N	N	N	N
Head Visibility	N	N	N	N
Mounting Height	N	N	N	N
Intervals/Phasing	N	N	N	N
Countdown Heads	NA	NA	NA	NA
Pedestrian Detectors				
ADA Ped Push Buttons (Y/N)	NA	NA	NA	NA
Push Button Location within Preferred Envelope [3] (Y/N)	NA	NA	NA	NA
Sign Nomenclature and Colors	NA	NA	NA	NA
Sign Size	NA	NA	NA	NA
Accessible Pedestrian Signals and Detectors	N/A	N/A	N/A	N/A
ADA Compliance				
Depressed Curb/Impediment to Accessibility (Y/N)	N	N	N	N
DWS on Ramps (Y/N)	Y	Y	Y	Y

Example:

In the example intersection, there is one maintenance corrective action and two modification corrective actions:

The maintenance corrective action is related to the Head Visibility field, as noted in example image 1. The reviewer noted that a pole-mounted sign was obscured by a tree (shown in example image 2). The red box highlights a One-Way sign that is hardly visible until within a few feet of the sign. The reviewer noted that this issue can be remedied with the maintenance corrective action of trimming back the tree.

The first modification corrective action is related to the vehicle signal head lateral positioning. Three approaches to the intersection have post-mounted signal heads that are less than 2 feet from the curb (one approach shown in example image 3).

Example Image 1 - Compliance Spreadsheet

Categories:	Compliance Issues by Intersection Approach				Comments	Corrective Action	
	NB	SB	EB	WB		Maint.	Modification
Vehicle Signal Heads							
Head Configuration/ Meaning	N	N	N	N			
Head Size	N	N	N	N			
Number of Heads	N	N	N	N			
Head Visibility	N	N	N	Y	Looks like pole mounted sign obscured by limbs/leaves	Trim trees/ branches	
Lateral Position	Y	N	Y	Y	Pole mounted heads are <2' from curb (4D.16)		Relocated signal heads (use upgrade opportunity to upgrade signal & place all heads overhead?

Example Image 2 -
One-Way Sign obscured by a tree

Example Image 3 -
Signal head less than 2 feet from curb